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The role of cattle in maintaining plant species diversity in wet dune valleys

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Abstract The succession of species-rich wetland vegetation in dune valleys into species-poor dwarf shrub vegetation was followed by means of permanent vegetation plots, in which the cover of vascular plant, moss and lichen species were recorded over a period of up to 33 years. Low density cattle grazing is an effective substitute for rabbits in stalling this succession, thus preserving the local plant species diversity. The influence of direct rabbit grazing pressure on the vegetation was studied in exclosures. The differences were significant, but not long-lasting after the exclosures had been opened again to the rabbits. *Cladina* lichen-rich *Empetrum*-heathland in the dunes is a stage in a probably cyclic succession that might be triggered by grazing. The total vascular plant, moss and lichen diversity of the dune ecosystem can be maintained by a combination of extensive cattle grazing and a regular but limited re-creation of pioneer situations.

Keywords Cattle · Dune · Lichen · Monitoring · Moss · Neophyte · Permanent plot · Vegetation · Vlieland · Wadden Sea

Introduction

The coastal dune region, and especially those of the West Frisian islands and part of the chain of barrier islands separating the Wadden Sea from the North Sea,

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constitute the most extensive natural region in The Netherlands, and the only one of international importance. While most of it is managed primarily as National Park or even Nature Reserve, there is much concern regarding the preservation of its unique plant species diversity (Van Dieren 1934, Dijkema and Wolff 1983, Westhoff and Van Oosten 1991, Ketner-Oostra and Sykora 2000, 2004).

There are several ongoing processes that influence the original plant species diversity in a largely negative way. Some are effects of human influence, like the increasing deposition of ammonia or the introduction of invasive plant species like *Rosa rugosa* and *Prunus serotina*, but the most important process is inherently natural, namely the succession of the vegetation. This succession generally leads from a species-poor pioneer vegetation, to (after only a few years) a species-rich herb vegetation that steadily decreases in plant species diversity again while the vegetation becomes dominated by shrubs and low trees. This trend appears in all vegetation types that occur (mixed in an intricate pattern) in the open dune biome.

The most important factor that retards this succession is (or rather was) rabbit grazing. However, subsequent virus infections nearly eradicated the rabbits. After myxomatosis in the late 50s and rabbit viral haemorrhagic disease (RVHD) in the late 80s (Drees 1992, Olff and Boersma 1998) the vegetation succession was seen to speed up. Nevertheless, other cause–effect relations are suggested as well (Bijlsma 2004). Mechanic mowing is not feasible in most of the area, as the terrain is rugged and the valleys are often accidented, very small. In an attempt to replace the rabbit grazing (and digging), low density cattle grazing was allowed in a dune area on the island of Vlieland in 1993, and the effects on the vegetation and the macrofauna was subsequently monitored (Van Wingerden et al. 2001, 2002).

The vegetation of the central part of Vlieland (53°17'N, 5°00'E) has been closely followed by means of permanent plots over a long period (1972–2005). The primary goal was to follow the succession in the various vegetation types (Aptroot 1985). In several cases, next to already existing permanent plots, exclosures were erected in 1974 to ban rabbit access for a few years. As the cattle grazing was started in part of the area covered by this research, a unique opportunity was created to evaluate and compare the effectivity of rabbits and cattle in retarding the succession.

Material and methods

Permanent vegetation plots, usually 3×3 m in size, were set out in horizontal, homogeneous vegetations in the central part of Vlieland, and the corners marked by durable wooden poles. The plots covered the main vegetation types of the valleys in the area. The locations of the plots are georeferenced by GPS. The combined abundance/cover percentage, as well as the fenology (vegetative/in buds/flowers/fruits) was noted for all vascular plant species, and the cover percentage of all moss and lichen species was recorded. The plots were always investigated in the last weeks of June, over a period spanning 33 years, usually by the first author. The plots were initially investigated every year, but later, when the rate of change declined, at irregular intervals. Several plots were surrounded by a mesh from 1974 to 1978, so as to form exclosures from rabbit grazing. Cattle grazing was allowed in part of the area from 1993 onward.

Nomenclature of vascular plants follows Van der Meijden (1996) and lichens Aptroot et al. (2004). All pictures were taken in June 2005.

Results

The dune landscape consists of several different vegetation types, not all of which were studied in detail. Four main vegetation types can be distinguished.

1. The species-rich dune valley wetlands ('Humid dune slacks' NATURA 2000 code: 2190) are floristically the richest element. These vegetations (known as Schoenetum) are largely confined to the Dutch coastal dunes, and preservation of the full range of plant species diversity is a top priority of nature conservation.
2. The dry *Empetrum* heathlands ('Decalcified fixed dunes with *Empetrum nigrum*' NATURA 2000 code: 2140) are a characteristic element of the Wadden Sea dunes. They are typically rich in *Cladina* lichens, and closer to boreal heathlands than to inland atlantic heathlands.
3. The wet heathlands (Ericion tetralicis vegetations) are relatively species-poor, and locally dominated by *Vaccinium macrocarpus*. The rare *Vaccinium uliginosum* is another boreal element that still occurs in the area (De Vries 1950, Aukes 2003).
4. The sand dunes ('Fixed dunes with herbaceous vegetation (grey dunes)' NATURA 2000 code: 2130) are quite rugged and the steeper slopes support additional vegetation types and species. Most characteristic of these sandy dunes is the presence on the sandy slopes of lichens, that usually occur epiphytically on tree bark. These vegetations are quite stable and still well developed in the area, with abundant *Hypogymnia physodes* and *Parmelia sulcata* (Fig. 1), and *Bryoria fuscescens* (which however seems to suffer from long distance ammonia pollution) still observed a few years ago. There is a strong difference in floristic composition between the North- and South-exposed slopes, which represent different vegetation types. No permanent plots cover any of these highly dynamic vegetations, but more information on these vegetations can be found in e.g. de Vries (1950) and van Wingerden et al. (2002).

Our observations are restricted to the vegetation and its components, with special emphasis on the cryptogamic species. No data were recorded concerning the macrofauna, but sampling by others in the same area over a (considerably shorter) period of one decade (Van Wingerden et al. 2001, 2002) revealed no major trends.

As the permanent plots were representative for the various vegetation types that occur in a mosaic-like pattern in the dune valleys, the different changes will be discussed by vegetation type.

Species-rich dune valley wetlands and the effect of cattle grazing

This vegetation is represented by plots 3 and 7. Both were about equally species-rich (23 resp. 21 species in 1974). In this type of vegetation (Schoenetum with Nanocyperion elements), not all plant species are found every year, but they may still be present in the form of tubers (e.g. in the case of orchids) or seeds (in the case of annuals). This accounts for the rather big differences in species numbers between

Fig. 1 Stable accidented sandy vegetations with terrestrial occurrence of the epiphytic lichens *Hypogymnia physodes* and *Parmelia sulcata*

consecutive years. Still, the overall trends are significant: floristic composition of the vegetations has shown considerable change over the years, especially in the first decade.

The general trends over the years are:

1) a loss of plant species diversity (Fig. 2);
2) an increase in vegetation cover percentage (Fig. 3);

These trends can be ascribed to natural, intrinsic succession of sandy dune wetlands, which support relatively more pioneer species when the vegetation is not yet

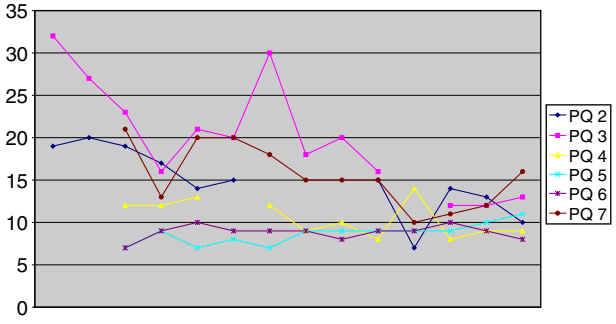

Fig. 2 Graphs of the number of herb species in the plots, 1972–2005, showing an overall loss of plant species diversity over time

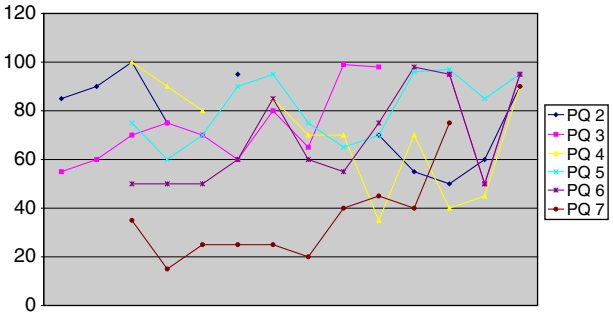

Fig. 3 Graphs of the percentage herb cover in the plots, 1972–2005, showing an increase in vegetation cover

closed. These Nanocyperion elements are replaced by (fewer) Schoenetum species, which are subsequently replaced by even fewer, more common wetland species.

Interestingly, plot 7 was in the area where cattle grazing started in 1993, but the similar plot 3 is outside the grazed area. Fresh cow droppings found in plot 7 in 2005 (Fig. 4) bear witness to actual grazing here. While both plots were largely identical in species richness and composition before grazing commenced, they are markedly different now. The ungrazed plot 3 continued its steady decrease in plant species diversity, and shrubs grew to a height of 1 m (Fig. 5), while the grazed plot 7 even regained some plant species diversity, and characteristic species like *Carex oederi* and *C. panicea* survived.

In conclusion, the cattle grazing seems to stall the intrinsic succession towards shrub vegetation, also concluded by Van Wingerden et al. (2001, 2002). In the 70s and 80s, the succession may have been retained by the than still abundant rabbits.

Lichen-rich dune heathlands and the effect of rabbit grazing

This vegetation is represented by plots 5 and 6, which are bordering each other. Plot 5 has been exclosed from grazing in the years 1974–1980. This vegetation is dominated by Ericaceae (*Calluna vulgaris*, *Empetrum nigrum* and *Erica tetralix* are

Fig. 4 Plot 7 with fresh cow droppings

Fig. 5 In the ungrazed plot 3 shrubs grow to a height of 1 m

co-dominant), but the plant species diversity and cover percentage is about equally high in the moss layer (lichens and mosses) as in the herbs + dwarf shrubs. Of special importance is the abundance of the lichen *Cladina ciliata* (Fig. 6), here growing together with *C. portentosa* (Fig. 7). These Reindeer lichens, together with the

Fig. 6 The Red Listed Reindeer lichen *Cladonia ciliata* in dune heathland

Fig. 7 The Reindeer lichen *Cladonia portentosa* in dune heathland

co-dominance of *Empetrum nigrum*, constitute a distinct boreal element in the Wadden Sea dune heathlands. Unexpectedly, this vegetation type is rather young, as *Empetrum* did not occur on the island of Vlieland until the beginning of the 20th century (de Vries 1950).

Currently, there is no agreement on the preferred management for these heathlands. The *Cladonia* Reindeer species are reported to vanish from certain areas, and various hypotheses have been put forward in explanation, most notably long range air pollution.

The present long term monitoring sheds at least some light upon this question, as it shows not only a rapid loss of the Red Listed *Cladonia ciliata* in plot 6 (Fig. 8), but also a gain, and subsequent loss of *Cladonia ciliata* in plot 5. The loss of *Cladonia ciliata* abundance is precisely dated in the long time series: in plot 6 it happened between June 1980 and June 1981, and in plot 5 between June 1983 and June 1984. No correlation with any other event was found. In between, that is between June 1981 and June 1982, the rapid gain of *Cladonia ciliata* abundance in plot 5 happened. This seems correlated with the release of rabbits into the plot again, after they had been excluded from 1974 until 1980.

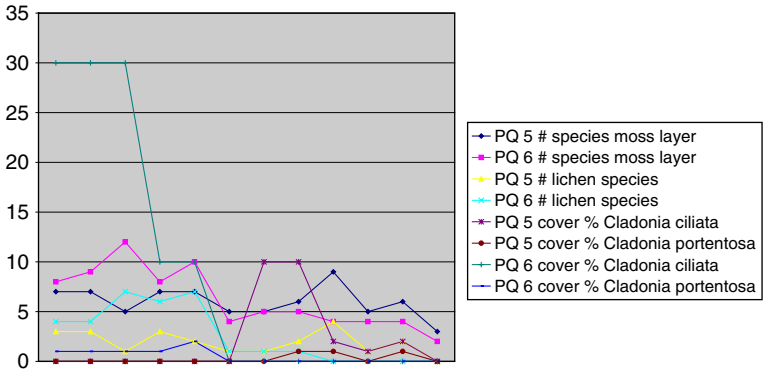

Fig. 8 Graphs of the number of moss and lichen species in the dune heathland, 1974–2005. plots and the cover percentage of *Cladonia ciliata* and *C. portentosa* in dune heathland

Fig. 9 Plots 5 (front) & 6 (back) with shrubs like *Lonicera periclymenum* and small trees like *Sorbus aucuparia*

The obvious, but not long-lasting, effect of the rabbit exclosure in plot 5 is a higher cover percentage of the herb + dwarf shrub layer, and the resulting even more significantly lower cover of the moss layer during that period.

By 2005, when rabbit grazing was down a minimum, all *Cladonia* species were gone from plots 5 and 6, and the moss + lichen species diversity was down to an all-time low. The newly arrived species (since 1987) are shrubs like *Lonicera periclymenum* and small trees like *Sorbu aucuparia* (Fig. 9), together with the grass *Deschampsia flexuosa*. Increase of these species in oligotrophic vegetation is usually attributed to ammonia pollution. However, *Cladonia*-rich dune heathlands, with species compositions like plot 6 in the 70s and plot 5 in the 80s are still common in the area. These heathlands are not (yet?) conspicuously better (or worse) developed in the grazed area than outside.

Two conclusions can be drawn from these observations:

1) Lichen richness in *Empetrum* heathland in the dunes is a stage in a probably cyclic succession;
2) It might be triggered by increased grazing.

Wet heathlands

The vegetation type that is here denoted as wet heathland is relatively species-poor, and largely dominated by the neophyte *Vaccinium macrocarpus*, which was spread by birds after an accidental introduction to the neighbouring Wadden Sea island Terschelling from a ship stranded in the 19th century. Apart from dwarf shrubs, Cyperaceae are dominant, with *Eleocharis multicaulis* vanishing, *Carex panicea* diminishing, and *Carex nigra*, *C. trinervis* and *Eriophorum angustifolium* increasing over the years.

The major change that occurred in this vegetation type is the steady loss of species richness (Fig. 2). *Erica tetralix* was a constant species in both plots until 1982/1983, but not found afterwards. At the same moment, *Agrostis canina* and *Danthonia decumbens* vanished. Two likely explanations that can be provided for this phenomenon are:

1) atonomous succession;
2) the invasion of the neophyte *Vaccinium macrocarpus*

Tempting as the second hypothesis be, it is not fully supported by the data. Admittedly, *Vaccinium macrocarpus* has a higher cover percentage now than ever before, but the loss of plant species diversity happened in the mid 80s, when the cover of *V. macrocarpus* was going down and lower than in the 70s.

From 1974 until 1978, plot 4 was exclosed from rabbit grazing. However, no significant differences with plot 2 developed, nor was there a sudden change after the vegetation was grazed again.

Two conclusions can be drawn from these observations:

1) Grazing seems not to be an important factor in the Cyperaceae-rich wet heathland valleys dominated by the neophyte *V. macrocarpus*;
2) The plant species diversity has decreased, probably due to succession, but the species composition seems to be stable now.

Discussion

Cattle grazing is in the past decennia increasingly used as a management tool in nature reserves. In many dune areas, including the island of Vlieland (de Vries 1950), some cattle grazing occurred, albeit for different purposes, until the beginning of the 20th century. However, the reported effects are not always positive, ranging from devastation of the sensitive species to a continuation of the impoverishment. Strongly negative effects have been especially observed in areas where the spatial variation of the vegetation is high. In such cases cows may graze in the shrub areas with low plant species diversity and subsequently redirect nutrients by depositing their dung on the herb vegetations with the high plant species diversity, inadvertently eradicating the prime target Red Listed species within a year or two. Obviously, some fine-tuning is needed in determining the cattle density, depending on the vegetation and especially the uniformity (of the lack thereof) of the landscape.

This paper provides long term data showing that the introduction of cattle in a complex dune area can indeed have a positive influence, replacing the vanished 'natural' herbivore, the rabbit. The herbivores are especially able to retard the succession from species-rich herb vegetations into species-poor shrubs.

In order to maintain the full plant species diversity, more is needed than grazing (Grootjans et al. 1995). Mechanic mowing is possible (and is actually applied) in a few flat grasslands. Some permanent plots were erected in these areas, but the marking poles had to be extracted every mowing time, and they vanished after a few years only, together with *Platanthera bifolia*. Also, many of the characteristic species of the open dune landscape are essentially pioneers. Those are species characteristic of early stages of colonization (Nanocyperion vegetations) like *Radiola linoides*, but also those characteristic of somewhat later stages in the succession, like *Pirola minor*. In order to keep (or periodically get) these pioneers present, rather drastic methods are called for. Small-scale removals of top layers are needed in places were such species were known to occur in former times, or geomorphologically similar places. On Vlieland, this has been occasionally done and the results are promising:

the species mentioned above, and in general most species that were lost in the permanent plots, are still present in the area, often in such artificial pioneer situations. With the current management, the future of the plant species diversity in our coastal dunes is bright.

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